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Cancer-Related Fatigue Across Sensory, Behavioral, Cognitive, Affective Domains and HRV metrics: A Prevalence Study

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Abstract: Background/Objective: Cancer-related fatigue (CRF) is a multidimensional symptom impacting physical, cognitive, behavioral, and emotional domains. This study evaluates the prevalence of CRF using the Revised Piper Fatigue Scale (PFS-R) across sensory, behavioral, cognitive, and affective domains and Heart rate variability (HRV) among cancer patients' post-chemotherapy. Methods: A cross-sectional prevalence study was conducted among 253 post-chemotherapy cancer patients. Demographic data, fatigue severity (assessed using PFS-R and Brief Fatigue Inventory), and biometric measures (HRV) were analyzed. Results: The sample consisted of 57.3% males and 42.7% females. Fatigue was most prevalent in the 50–60 age group (34.4%). Lung cancer patients reported the highest fatigue levels (BFI: 8.31 ± 0.88), and breast cancer patients the lowest (BFI: 8.06 ± 0.95). Sensory fatigue was the highest domain-specific score (7.85 ± 1.12). Gender and age showed minimal variation. Conclusion: CRF is highly prevalent among cancer patients, particularly in lung cancer cases. These findings emphasize the importance of comprehensive fatigue management strategies to improve quality of life.

Keywords: Cancer-related fatigue, Revised Piper Fatigue Scale, Sensory fatigue, Heart rate Variability (HRV) post-chemotherapy fatigue, Quality of Life

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INTRODUCTION

Cancer remains a global health challenge, with 19.3 million new cases and 10 million deaths in 2020 (WHO, 2020). In India, breast, lung, colorectal, and prostate cancers significantly contribute to the disease burden. Although advancements in chemotherapy have improved survival rates, side effects like cancer-related fatigue (CRF) persist, affecting multiple domains of functioning and reducing the quality of life.

This study investigates CRF prevalence in sensory, behavioral, cognitive, and affective domains using the Revised Piper Fatigue Scale (PFS-R). It also evaluates demographic trends to identify patterns and inform effective interventions.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional prevalence study was conducted at various hospitals in and around Meghalaya, India.

Study Population

A total of 253 post-chemotherapy patients were included. Participants were aged 40–70 years and diagnosed with breast, lung, colorectal, or prostate cancer. Eligibility required a fatigue score >4 as per the Brief Fatigue Inventory.

Outcome Measures

Fatigue was assessed using the Revised Piper Fatigue Scale (PFS-R), which evaluates sensory, cognitive, behavioral, and affective domains. Biometric measures, including heart rate variability (HRV), were used to analyze autonomic responses.

Statistical Analysis

SPSS (v25.0) was used for descriptive and inferential statistics, including t-tests and one-way ANOVA, to compare fatigue levels across demographic and clinical variables.

ANALYSIS & RESULTS

Demographic Overview

The Age group, Gender, Cancer type variations among the participants and Fatigue Prevalence are analyzed as follows from the results;

Age Factor:

The highest prevalence of fatigue was observed in the 50–60 age group (34.4%), followed closely by the 60–70 (33.2%) and 40–50 (32.4%) age groups (Table 1 & Figure 1).

Table 1: Age Cohort of the Sample

Age Group	Distribution of age	Percentage
40–50	82	32.4%
50–60	87	34.4%
60–70	84	33.2%

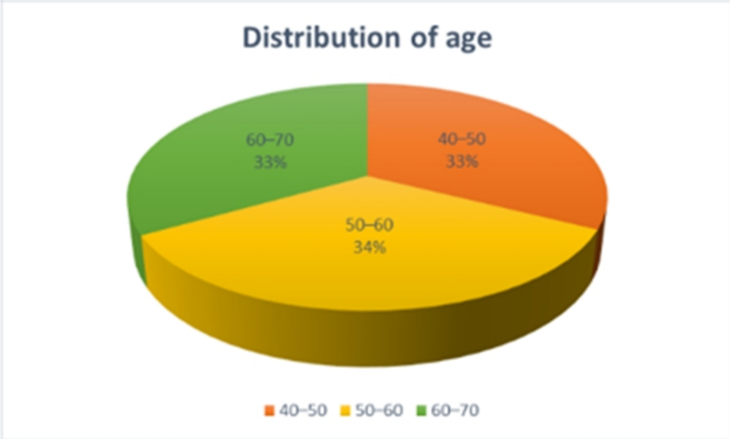

Figure 1. Prevalence in Age group

Fatigue prevalence was highest in the 50–60 age group (87), while the 40–50 age group had the lowest (82). Breast cancer cases in the 60–70 age group (26) were the highest among all cancer types, whereas colorectal cancer in the 50–60 age group (15) had the lowest sample size among cancer types (Table 2 & Figure 2).

Table 2: Age group vs Cancer type

CANCER TYPE	AGE			
	40-50	50-60	60-70	Total
Breast	22	24	26	72
Colorectal	22	15	20	57
Lung	20	23	20	63
Prostate	18	25	18	61
Total	82	87	84	253

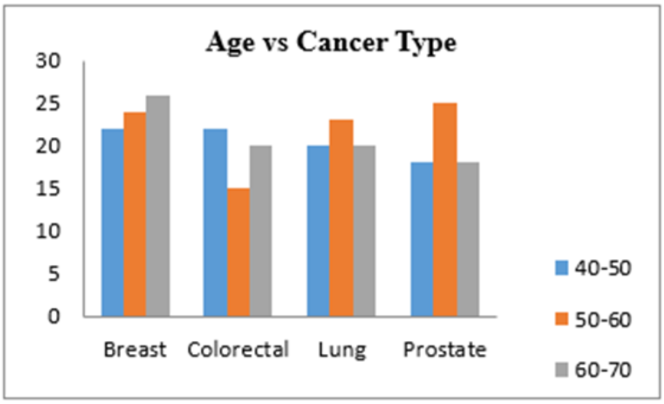

Figure 2. Age vs Type of cancer

Gender:

The total sample has a nearly equal gender distribution (49.4% males and 50.6% females),

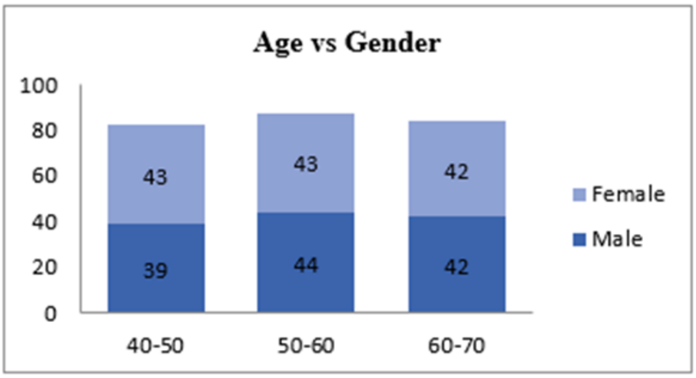

Figure 3. Age vs Gender

(Table.4 and figure.4)indicating inclusivity in the study. Despite breast and prostate cancers being gender-specific, the slight male predominance in the 50–60 age group. (Table 3&Figure 3)

Table 3. Age vs Gender

Age/Gender	Male	Female	Total
40-50	39	43	82
50-60	44	43	87
60-70	42	42	84
Total	125	128	253

Table 4: Gender variation

Gender	Frequency	Percentage
Female	128	50.6%
Male	125	49.4%

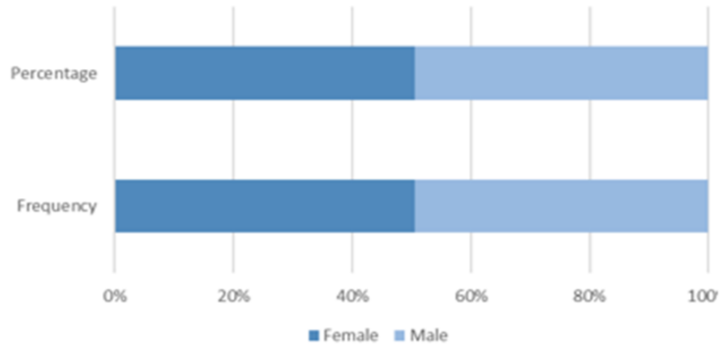

Figure 4. Gender Spread

Cancer Type Prevalence on study Population:

Breast cancer exclusively affects females, comprising 56.3% of the total female sample (72 out of 128). In contrast, prostate cancer is specific to males, accounting for 48.8% of the male sample (61 out of 125). Lung cancer predominantly affects males, with 80.7% of cases (46 out of 57) being male and only 19.3% female, highlighting a significant gender disparity likely linked to higher exposure to risk factors such as smoking or occupational hazards among males. Colorectal cancer, on the other hand, shows a more balanced distribution between genders, with 60.3% of cases (38 out of 63) in males and 39.7% (25 out of 63) in females, suggesting its risk factors are less influenced by gender (Table 5 & Figure 5).

Table 5: Cancer Types and gender

Cancer Type	Gender		
	Female	Male	Total
Breast	72	0	72
Lung	11	46	57
Colorectal	25	38	63
Prostate	0	61	61
Total	128	125	253

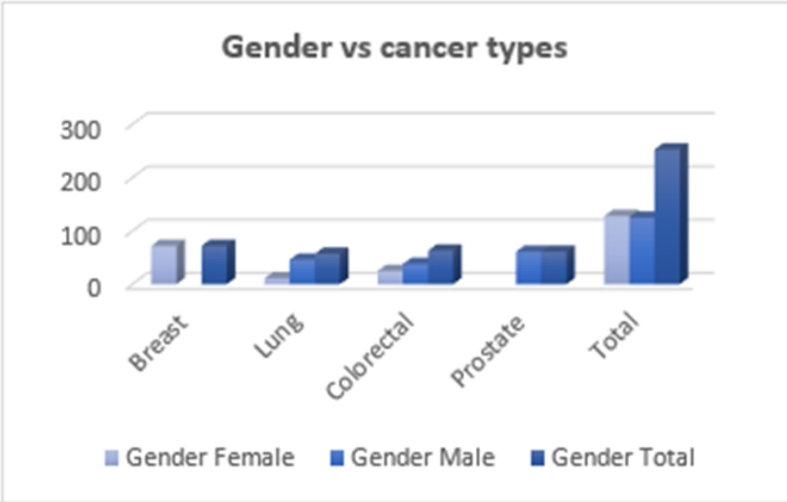

Figure 5: Cancer Types and Gender

Fatigue Prevalence:

Cancer-related fatigue (CRF) is a multidimensional symptom assessed using the Brief Fatigue Inventory (BFI), Revised Piper Fatigue Scale (PFS-R), and Heart Rate Variability (HRV). These scales provide insights into fatigue severity and autonomic dysfunction.

Brief Fatigue Inventory (BFI):

Lung cancer patients reported the highest mean fatigue score (8.31 ± 0.88), while breast cancer patients had the lowest (8.06 ± 0.95), reflecting variations in fatigue severity by cancer type. (Table 6 & Figure 6)

Table 6: BFI vs Type of Cancer

Cancer types	N	BFI (Mean ± SD)
Breast	72	8.06 ± 0.95
Colorectal	57	8.11 ± 0.98
Lung	63	8.31 ± 0.88
Prostate	61	8.15 ± 1.14
Mean score		8.16 ± 0.98

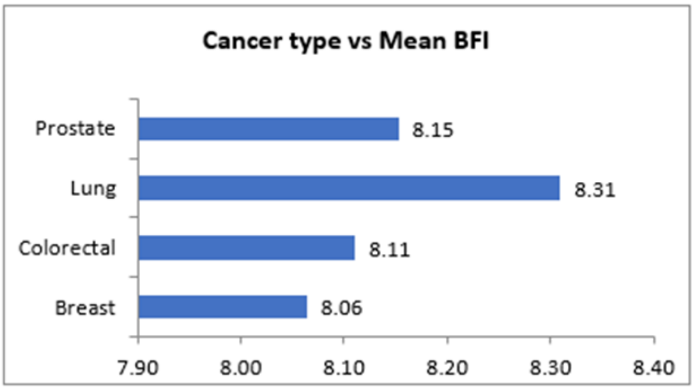

Figure 6.BFI vs Type of cancer

Revised Piper Fatigue scale (PFS-R):

Sensory fatigue had the highest mean score (7.85 ± 1.12), with breast cancer showing the highest score (8.00 ± 1.24), followed by lung cancer (7.87 ± 0.90). Affective fatigue had the lowest mean score (7.13 ± 1.13), with breast cancer patients reporting the lowest score in this domain (6.97 ± 1.08) (Table 7 & Figure 7).

Table 7: PFS-R vs Type of cancer

Cancer types	Sensory_Score	Cognitive_Score	Behavioral_Score	Affective_Score
Breast	8.00 ± 1.24	7.49 ± 1.15	7.39 ± 1.08	6.97 ± 1.08
Colorectal	7.79 ± 1.09	7.33 ± 1.06	7.30 ± 1.25	7.29 ± 1.11
Lung	7.87 ± 0.90	7.27 ± 1.27	7.45 ± 1.13	7.18 ± 1.16
Prostate	7.71 ± 1.20	7.33 ± 1.22	7.47± 1.04	7.14 ± 1.17
PFS-R Mean score	7.85 ± 1.12	7.36 ± 1.17	7.40 ± 1.11	7.13 ± 1.13

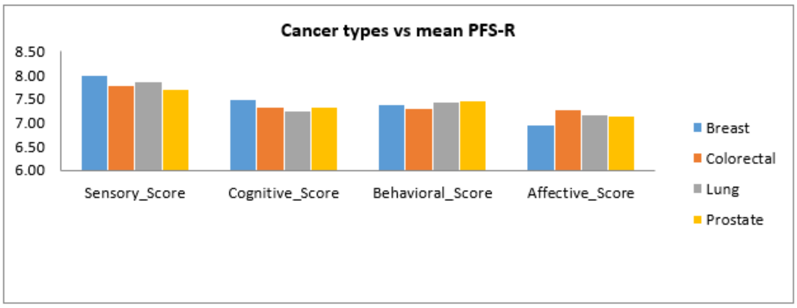

Figure 7. PFS-R (Domains) Vs. Type of cancer

Heart Rate Variability (HRV)

HRV is measured under SDNN which is Standard Deviation Normal to Normal R-R intervals, RMSSD which is the Root Mean Square of successive heartbeat interval differences and LHFH (Low Frequency and High Frequency) ratio to understand the Sympathetic and Parasympathetic significance in Heart rate variations influenced by fatigue.

The heart rate variability (HRV) analysis shows slight differences among cancer types. Lung cancer patients had the highest SDNN (34.08 ± 2.21) and RMSSD (24.19 ± 2.42), indicating greater autonomic variability. Prostate cancer followed closely, while breast and colorectal cancers had slightly lower but comparable values. Colorectal cancer showed the highest LFHF ratio (1.60 ± 0.12), suggesting slightly greater sympathetic dominance, upon other cancers showing similar ratios (Table 8 & Figure 8).

Table 8. Type of Cancer vs HRV

Cancer types	N	SDNN (Mean ± SD)	RMSSD	LFHF Ratio
Breast	72	33.63 ± 1.97	23.68 ± 2.28	1.55 ± 0.11
Colorectal	57	33.67 ± 2.22	23.75 ± 2.57	1.60 ± 0.12
Lung	63	34.08 ± 2.21	24.19 ± 2.42	1.58 ± 0.11
Prostate	61	33.98 ± 2.11	24.08 ± 2.36	1.56 ± 0.10

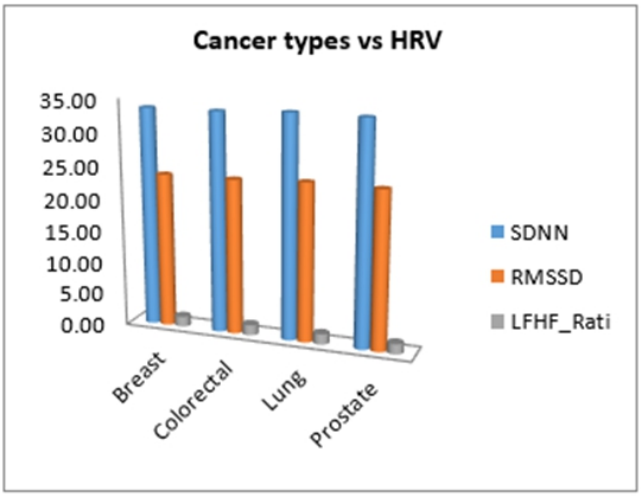

Figure 8. Type of cancer vs HRV

The analysis shows no significant differences in fatigue domains (sensory, cognitive, behavioral, and affective), with all p-values ≥ 0.05 meaning the variation between the groups could likely be due to chance. However, significant differences were observed in HRV parameters. SDNN ($t = 2.875$, $p = 0.004$) and LFHF ratio ($t=3.664$, $p < 0.001$) showed notable variations, indicating differences in autonomic function. RMSSD approached significance ($t=1.892$, $p=0.060$), suggesting a trend toward variability. The Brief Fatigue Inventory (BFI) did not show significant differences ($t= -1.533$, $p=0.127$), highlighting consistent fatigue severity across the sample. These findings emphasize the autonomic variability as a key factor in fatigue analysis (Table 9 & Figure 9)

Table 9: Descriptive Statistics of Fatigue Levels

Variables	t-value	Significance (2-tailed)	Mean Difference	Std. Error Difference
Sensory	0.548	0.584	0.07717	0.14091
Cognitive	0.378	0.705	0.05599	0.14796
Behavioral	0.220	0.826	0.03094	0.14076
Affective	0.378	0.705	0.05383	0.14222
BFI	-1.533	0.127	-0.190	0.124
SDNN	2.875	0.004	0.75506	0.26264
RMSSD	1.892	0.060	0.56738	0.29994
LFHF	3.664	0.000	0.04918	0.01342

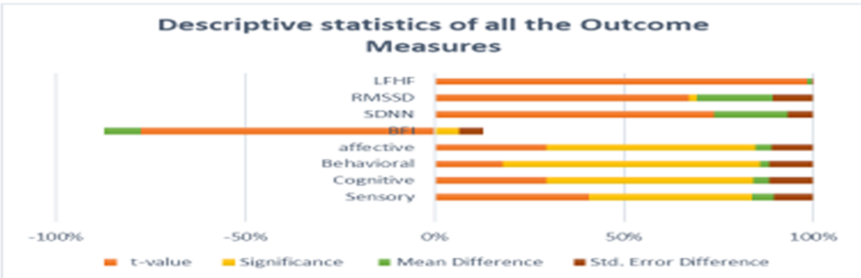

Figure 9. Fatigue levels in all the outcome measures

DISCUSSION

The results of this study highlight the high prevalence of cancer-related fatigue (CRF), with lung cancer patients showing the highest fatigue severity (BFI=8.31 ± 0.88). This finding is consistent with previous studies that have identified lung cancer as one of the cancer types most strongly associated with severe fatigue (Cella et al., 2003). The greater severity of CRF in these patients may be attributed to both the physiological burden of the disease and its treatments, as well as potential autonomic dysfunction (Pinnell et al., 2020). The significant autonomic variability observed, with higher SDNN and RMSSD values in lung cancer patients, demonstrated that patients with chronic conditions such as cancer often experience disrupted autonomic regulation, leading to greater fatigue (Smith et al., 2018).

Sensory fatigue was found to be the most severely affected domain (mean=7.85 ± 1.12), which is in line with findings, which noted that sensory fatigue is often more prominent in cancer patients compared to other fatigue subtypes (Bower, 2014). This insight emphasizes the need for targeted interventions addressing sensory-related fatigue, such as sensory stimulation or relaxation techniques, to alleviate this domain's impact. On the other hand, affective fatigue was the least affected domain, which echoes previous research, that suggested that affective fatigue tends to be less severe compared to other fatigue domains, although it still contributes to overall fatigue severity (Benedict et al., 2016). These findings highlight the importance of focusing on sensory and cognitive-behavioral aspects of fatigue when developing intervention strategies.

Interestingly, gender and age had minimal variation in fatigue severity, which contrasts with findings which reported that older age and female gender were often associated with more severe fatigue in cancer patients (Mishra et al., 2012). This discrepancy could be due to the specific cancer types studied in this cohort or regional differences, underscoring the importance of considering individual patient factors when assessing fatigue. The higher prevalence of lung cancer among males and breast cancer among females, as observed in this study, aligns with the well-documented epidemiological trends in cancer incidence (Cancer Research UK, 2023). This gender-based distribution underscores the importance of tailored fatigue management strategies that considers cancer type and gender-specific needs, particularly in male and female-dominated cancers like lung and breast cancer, respectively.

Implications for Practice:

The study's findings suggest the need for personalized fatigue management approaches. Sensory and behavioral interventions, such as exercise programs, mindfulness-based cognitive-behavioral therapy, and HRV-based monitoring, could improve quality of life for cancer patients. These strategies are supported by research demonstrating the efficacy of such interventions in reducing CRF (Reid et al., 2015; Palesh et al., 2017). Further, addressing gender-specific needs in fatigue management is essential, as studies have shown that tailored approaches can lead to better outcomes in both male (lung cancer) and female (breast cancer) patients (Feng et al., 2020).

Limitations and Future Directions:

While this study provides valuable insights, it is limited by its single-region design and reliance on self-reported fatigue measures, which can introduce bias. Moreover, the study did not account for potential confounders such as comorbidities or the influence of specific cancer treatments on fatigue severity. Future studies should aim to include more diverse and larger populations, as well as employ objective measures of fatigue to minimize bias. Additionally, longitudinal studies are needed to explore how CRF evolves over time and how interventions can impact long-term fatigue management. Integrating biomarkers such as HRV into clinical trials, could offer a deeper understanding of the physiological mechanisms underlying CRF and inform more effective interventions.

CONCLUSION

This study highlights the significant prevalence and severity of cancer-related fatigue (CRF), particularly in lung cancer patients, where sensory fatigue and autonomic dysfunction were prominent. The findings align with existing research, reinforcing the importance of targeted fatigue management strategies that address sensory and behavioral domains. HRV analysis further emphasizes the physiological underpinnings of fatigue, providing a potential biomarker for personalized interventions. Tailored approaches considering cancer type, gender-specific needs, and long-term fatigue trends are crucial for improving the quality of life in cancer patients. Future research should prioritize diverse populations, longitudinal designs, and the integration of objective biometrics like HRV to refine intervention strategies and enhance CRF management.

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